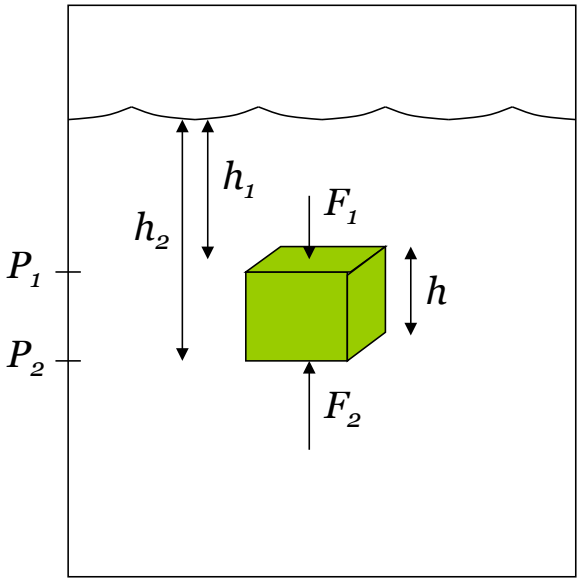
Knight: Chapter 15

Fluids & Elasticity

(Buoyancy & Fluid Dynamics)

Buoyancy

Q: Why do things feel lighter underwater (or even float)?



Imagine a block in a fluid...

$P_2 = P_0 + \rho g h_2$

$P_1 = P_0 + \rho g h_1$

$P_2 - P_1 = \rho g (h_2 - h_1) = \rho g h$

$P_2 A - P_1 A = \rho g h A$

$F_2 - F_1 = \rho V g$

$F_B = \rho V g$

Archimedes' principle

The buoyant force is equal to the ***weight of the fluid displaced****.*

$$F_B = \rho_f V_f g$$

Quiz Question 1

Imagine holding two bricks under water. Brick *A* is just beneath the surface of the water, while Brick *B* is at a greater depth.

The force needed to hold Brick *B* in place is

1. larger than
2. the same as
3. smaller than

the force required to hold Brick *A* in place.

Quiz Question 2/Demo

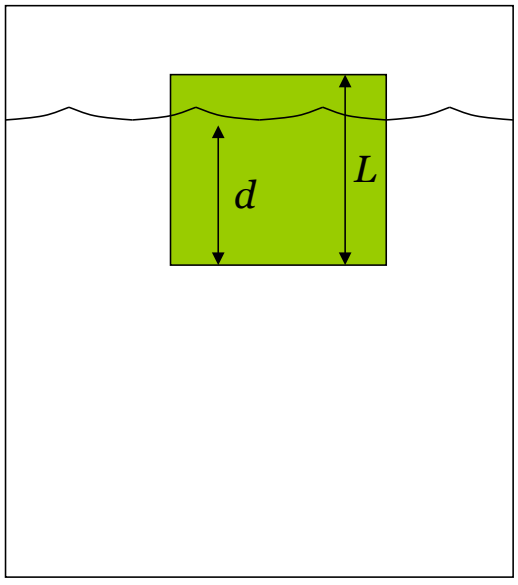
Which scenario displays more water?

1. the rock
2. the rock on the float
3. Both displace the same amount of water.

i.e.2: Ice cube

How much of the ice cube's mass is *below* the surface of the water?

(The density of liquid and solid water are, respectively, ρ_{H2O}= 1,000 kg/m^3 and ρ_{ice}= 917 kg/m^3.)



$F_B = m_{H_2O} g$

$= \rho_{H_2O} V_{H_2O} g$

$= Ad$

$F_B - mg = 0$

$F_B = mg$

$m_I = \rho_I V_I$

$= \rho_I A l$

Quiz Question 3

A tin can has a volume of 0.001 m^3 and a mass of 0.1 kg. Approximately how many grams of lead shot can it carry without sinking in water:

$w = 0.98$

$\mu_B = \mu_c + \frac{F}{g}$

$\mu_c + \rho_{h_2o}$

1. 100
2. 900
3. 980
4. 1000
5. 1100

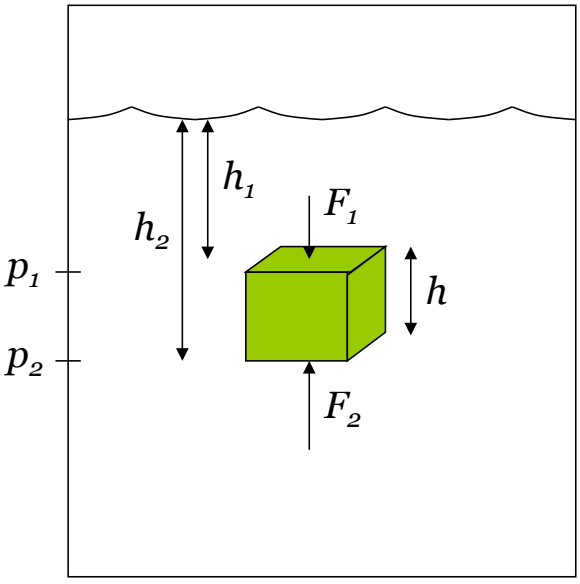
Fluid dynamics

Ideal-fluid model

- Incompressible (ρ = *constant*)
- Nonviscous (water, not syrup)
- Laminar flow (no turbulence)

Questions…

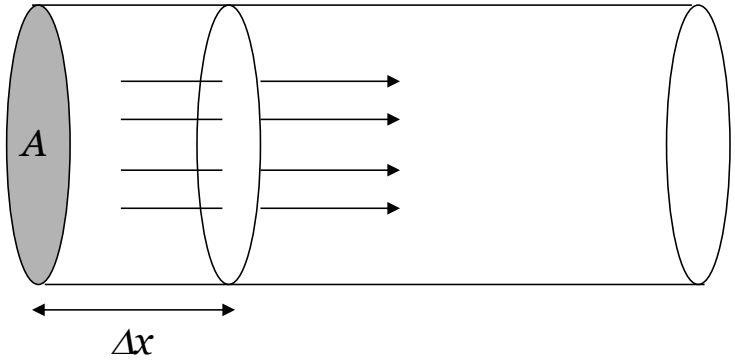
Imagine the block in an *ideal fluid*…



- How does p_1 compare with p_2 ?
- How does ρ_1 compare with ρ_2 ?

Fluids dynamics…

Consider fluid flowing down a cylindrical pipe…



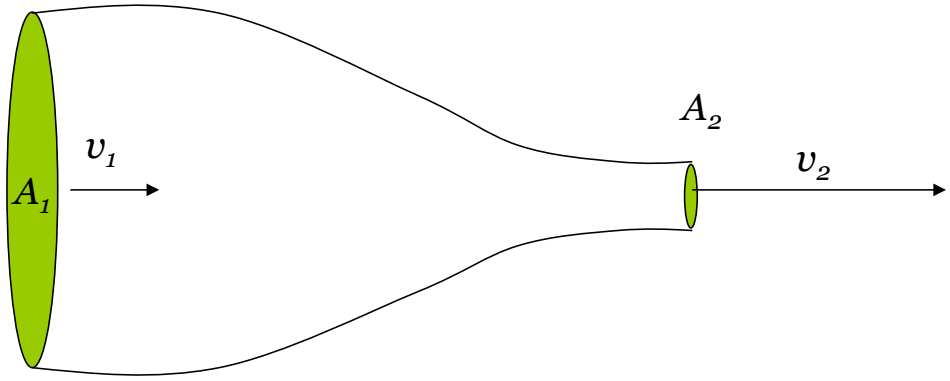
What is the "Flow Rate"?

$$Q = \frac{A\Delta x}{\Delta t} = Av$$

Equation of Continuity

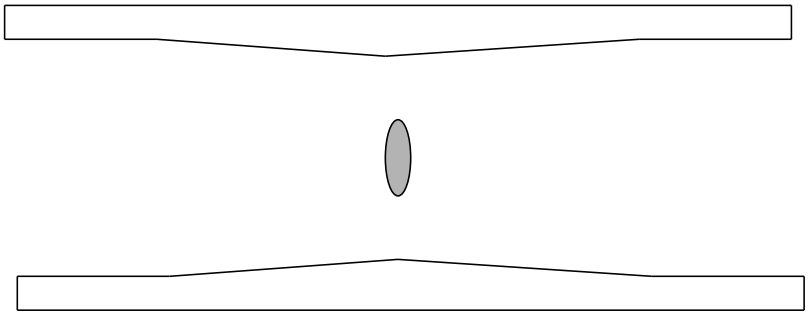
$$(\text{Volume/time})_{\text{in}} = (\text{Volume/time})_{\text{out}}$$

$$v_1 A_1 = v_2 A_2$$



Quiz Question 4

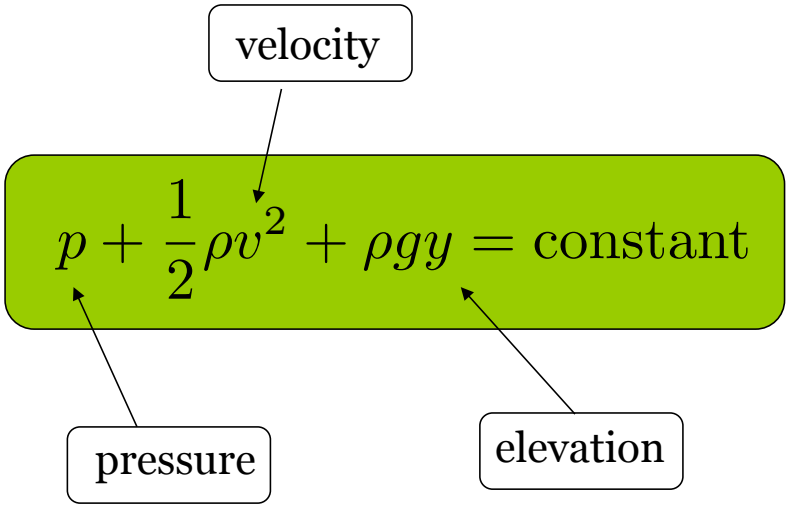
A blood platelet drifts along with the flow of blood through an artery that is partially blocked by a stenosis. As the platelet is moving through the stenotic region, its *speed* (in the stenotic region) is:



1. increased
2. decreased
3. unchanged

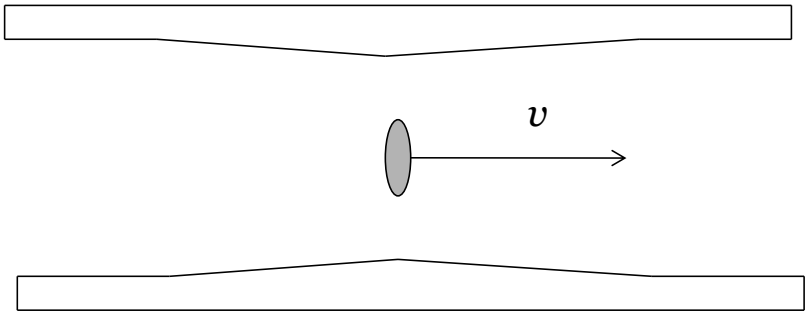
Bernoulli's Equation

Conservation of energy yields:



Quiz Question 5

A blood platelet drifts along with the flow of blood through an artery that is partially blocked by a stenosis. As the platelet is moving through the stenotic region, the *pressure* (in the stenotic region) is:



1. larger than
2. smaller than
3. the same as

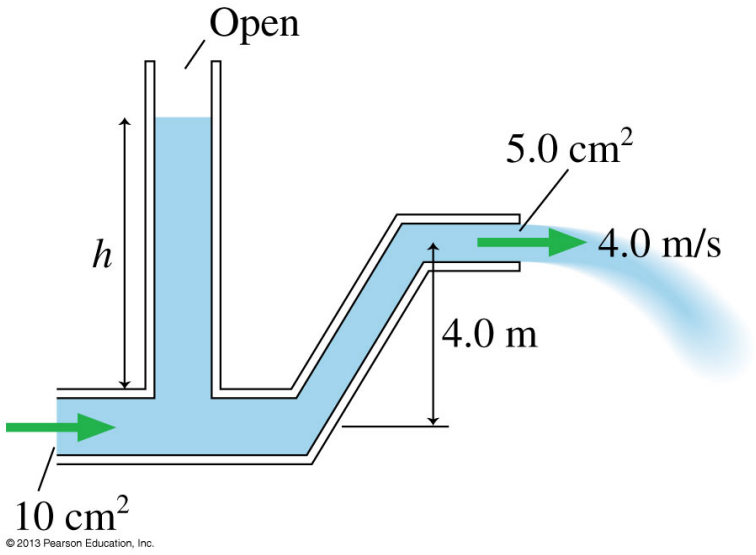
the non-stenotic region.

Prob. 15.60

Water flows from the pipe shown in the figure below with a speed of 4.0 m/s.

a. What is the water pressure as it exits into the air?

b. What is the height *h* of the standing column of water?



i.e.1: Weather balloon

A 600-kg weather balloon is designed to lift a 4,000-kg package.

What volume should the balloon have after being inflated with helium in order for the total load to be lifted?

(The density of helium and air are, respectively, ρ_{He}= 0.179 kg/m^3 , ρ_{Air}= 1.28 kg/m^3 at standard temperature and pressure)